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Metacognition and mindreading in young children: A cross-cultural study

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ABSTRACT

Prior studies document cross cultural variation in the developmental onset of mindreading. In particular, Japanese children are reported to pass a standard false belief task later than children from Western countries. By contrast, we know little about cross-cultural variation in young children's metacognitive abilities. Moreover, one prominent theoretical discussion in developmental psychology focuses on the relation between metacognition and mindreading. Here we investigated the relation between mindreading and metacognition (both implicit and explicit) by testing 4-year-old Japanese and German children. We found no difference in metacognition between the two cultural groups. By contrast, Japanese children showed lower performance than German children replicating cultural differences in mindreading. Finally, metacognition and mindreading were not related in either group. We discuss the findings in light of the existing theoretical accounts of the relation between metacognition and mindreading.

1. Introduction

Mindreading is the ability to understand that people (others and oneself) have specific mental states. Little is known about the cultural diversity of this crucial component of social cognition. Is our understanding of others' mind and our own mind universally shared across different cultures? Prior studies document cultural variation in mindreading in children and adults (see Kobayashi, Glover, & Temple, 2007; Lillard, 1998; Slaughter & Perez-Zapata, 2014), potentially yielding to misinterpret mental states in individuals from other cultures (e.g., Adams Jr. et al., 2010). In contrast, we know almost nothing about possible cultural variations in metacognition, that is, in the ability to monitor and control one's own mental states and cognitive activities. This is all the more surprising given that developmental studies and theories have suggested a relation between mindreading and metacognition (e.g., Carruthers, 2009a, 2009b; Lecce, Demicheli, Zocchi, & Palladino, 2015; Lockl & Schneider, 2007; Perner, 2000).

In the present research, we aimed at addressing two questions. First, we asked whether Japanese and German children differ in the development of their metacognitive abilities, specifically in their access to, and understanding of, their own knowledge states. Second, we explored whether or not the development of their metacognitive abilities are related to their mindreading ability. Below,

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we first review a body of studies on cross-cultural differences in the development of mindreading. Do the variations in mindreading documented in the literature suggest that similar variations are present in metacognition? We will present an argument for a positive answer to this question. We will see, however, that the distinction between implicit (defined as an appreciation of one's own cognitive outcomes without a conceptual understanding but based on non-conscious associative heuristics) and explicit (defined as an evaluation of one's own cognitive outcomes that involve a conceptual understanding) metacognition requires a more complex approach. Finally, we will present our experiment.

1.1. Cultural variation in mindreading

Mindreading ability in young children is largely studied via a standard false belief task, which taps on an understanding of the representational nature of a mind distinct from reality (Wimmer & Perner, 1983). In this task, a protagonist character leaves something behind in a certain location; while s/he is absent, another person moves it to a different location. Children are then asked where the protagonist character will look for the object when s/he returns. By the age of 5, children understand that the protagonist character possesses a false belief, and that s/he will act on the basis of his/her false belief, and will therefore respond that s/he will look for the object in its initial location where s/he left it. Children younger than 5, by contrast, respond that the character will look for the object in the location where the object actually is. The findings are quite robust across multiple studies with using different versions of the task (Wellman, Cross, & Watson, 2001; Wellman & Liu, 2004).

The development of mindreading, however, has been shown to vary across different cultures (Callaghan et al., 2005; Liu, Wellman, Tardif, & Sabbagh, 2008; Mayer & Trauble, 2015; Vinden, 1999; see Lillard, 1998; Slaughter & Perez-Zapata, 2014; Wellman, Fang, Liu, Zhu, & Liu, 2006; Sodian & Kristen, 2016, for reviews). A meta-analysis showed a universal sequence of the developmental trajectory of mindreading, but the developmental onset of false belief understanding differs as a function of the countries in which children develop, and of the languages that they speak and listen to (Liu et al., 2008). For example, as compared to children from Western countries (e.g., US, UK, Canada), Japanese children pass standard false belief tasks at a later age than the age of five (Hughes et al., 2014; Liu et al., 2008) and understand others' actions in terms of social constraints rather than mental states (e.g., Naito & Koyama, 2006). Some evidence even challenges the universal sequence of mindreading development. For example, children from certain cultures understand the role of perception or testimony in acquiring knowledge before they understand that different people may have different beliefs (e.g., Slaughter & Perez-Zapata, 2014; Wellman et al., 2006).

An explanation for such cultural variation in the development of mindreading is that cultures vary in the extent to which people view mental states as underlying causes for behaviors, and the frequency in which mental states are used to explain behavior in everyday conversation (Lillard, 1998). In cultures typically characterized as individualistic as opposed to collectivistic, adults tend to view one's behavior and others' as internally motivated as opposed to constrained by situation/context and social rule and norms (e.g., Nisbett & Masuda, 2003). Additionally, parents' use of mental state language in their conversation with children varies by culture (e.g., Wang, Doan, & Song, 2010).

1.2. Metacognition and its relation to mindreading

Theoretically, metacognition has been argued to be closely related to mindreading. Some authors, in particular, view metacognition as stemming from mindreading. This hypothesis is usually associated with the view that the type of mindreading that is relevant to metacognition consists in the explicit understanding that one's mental states explain cognitive and behavioral decisions (e.g., Carruthers, 2009a, 2009b; Chandler & Carpendale, 1996; Efklides, 2008; Goldman, 2006; Flavell, 2000; Kuhn, 2000; but see Nichols & Stich, 2003 for an independent process argument). Hence, metacognition is considered to depend on the ability to attribute mental states to oneself. Empirical evidence indeed suggests that children's false belief understanding is predictive of their metamemory. Lockl and Schneider (2007) demonstrated that German children's false belief understanding at the age of 3 and 4 predicted later verbal metamemory at the age of 5 after controlling for language competencies. They also found that although language abilities independently predicted later metamemory, false belief understanding at the age of 4 contributed more than language to predicting metamemory at the age of 5. Lecce and colleagues corroborated these findings by demonstrating that the predictive relationship between mindreading and metamemory is specific to cognitive (i.e., false belief understanding) not affective (i.e., empathic understanding of others' emotions) mindreading, controlling for other related factors such as working memory. They further demonstrated that early cognitive mindreading predicts later metamemory, while early metamemory does not predict later cognitive mindreading (Lecce et al., 2015; see also Ebert, 2015). They further showed that Italian 4- and 5-year old children who were trained in false belief tasks did better in a verbal metamemory task than a control group, both in post-test and 2 months after training, thus documenting a causal direction between mindreading and metamemory (Lecce, Bianco, Demicheli, & Cavallini, 2014).

While many existing studies have examined cultural diversity in children's mindreading as discussed above (see 1.1.), no study has explored cultural diversity in children's metacognition. Based on the theoretical claims on the relationship between mindreading and metacognition, two possible predictions can be made. On one hand, the theoretical account and evidence above suggesting a close relationship between these two skills predict cultural differences in the development of metacognition that parallel the cultural differences in the development of mindreading. Alternatively, we may not see the parallel in the cultural differences in the development of metacognition and mindreading. It could be either because these two skills involve separate mechanisms and processes and follow different developmental timelines (e.g., Nichols & Stich, 2003; Proust, 2019), or because attributing mental states to oneself in metacognitive evaluation might not be driven by the same cultural rules as is the case when attributing mental states to others in false belief tasks. Note that there are different arguments for specific mechanisms even among the proponents of a close relationship

between mindreading and metacognition, and we did not intend to test these but rather simply asked whether the two cognitive abilities are related or not.

1.3. Implicit and explicit metacognition and mindreading

Note that all the aforementioned developmental studies concern explicit metacognition and mindreading. By definition, this form of metacognition and mindreading requires one to explicitly (i.e., verbally) represent one's own and others' mental states and processes. While studies using verbal assessment suggest a late development of metacognitive abilities (e.g., Schneider, 2008), studies using non-verbal, i.e. 'implicit' measures find evidence for early metacognitive abilities: in infants (Goupil, Romand-Monnier & Kouider, 2016), in very young children (Balcomb & Gerken, 2008; Gerken, Balcomb, & Minton, 2011; Lyons & Ghetti, 2013; Paulus, Proust, & Sodian, 2013) and in nonhuman animals (e.g., Kornell, Son, & Terrace, 2007; Neldner, Collier-Baker, & Nielsen, 2015; Smith, Beran, Couchman, & Coutinho, 2008 for a review). For example, Balcomb and Gerken (2008) demonstrated that 3.5-year-old children were more likely to decline to answer to the memory trials in which they were uncertain (than when they were certain) to succeed. In another study, Kim, Paulus, Sodian, and Proust (2016) found that whereas 3- and 4-year-old children tended to overestimate their own knowledge when asked to verbally report the hidden contents of a box (i.e., reporting that they knew what was in the box), the same children did not do so when accepting or declining to inform another person (i.e., being more likely to decline informing) – in particular in the partial knowledge condition (described below). Thus, the findings indicate a discrepancy between explicit and implicit forms of metacognition (see, Frith, 2012). The explicit version of the task in Kim et al. (2016) adopted the same task as Rohwer, Kloo, and Perner (2012). In Rohwer et al. (2012), Austrian children, by already 3 years old, performed well in the typical conditions that tested an understanding that visual access determines knowledge, accurately reporting that they do vs. do not know when they do vs. do not see the hidden contents of a container (e.g., Pratt & Bryant, 1990). In contrast, they performed poorly until the age of 6 in the partial knowledge condition, in which they were shown two objects, were told that only one of the objects would be hidden, but did not see the actual hiding. Based on these findings, the authors argued that young children do not reliably understand that access to information determines knowledge (or that seeing-leads-to-knowing) but instead rely upon "a feeling of competence" generated by an immature cognitive heuristics (having seen all the objects to be hidden, they thought that they were in a position to know which object was currently hidden). According to Rohwer et al. (2012), therefore, children's explicit metacognitive ability of assessing their own ignorance is still incompletely developed. In summary, an increasing number of recent studies document an implicit form of metacognition in young children. A more complex approach to the relationship between mindreading and metacognition is clearly needed.

A similar gap between implicit and explicit forms has also been documented in mindreading abilities. While only by 5 years of age do children in Western countries pass a standard false belief task, infants seem to display some kind of sensitivity to others' false beliefs when using an implicit measure such as eye gaze (e.g., Onishi, & Baillargeon, 2005) or in communicative or interactive contexts (e.g., Buttelmann, Carpetner, & Tomasello, 2009). Note, however, that the nature of these findings is heavily debated (e.g., Kammermeier & Paulus, 2018; Poulin-Dubois et al., 2018). Nonetheless, there seems to exist implicit or automatic processes in mindreading and metacognitive skills even though their developmental origin is disputed (see Apperly & Butterfill, 2009; Heyes & Frith, 2014).

Given that prior studies exclusively tested explicit forms of mindreading and metacognition, the relationship between their implicit forms is not unambiguously specified in theories or fully understood empirically. An exception is Bernard, Proust, and Clement (2015) who found no relationship between implicit metacognition and explicit mindreading in children of ages 3–5. Because Bernard et al. (2015) compared explicit mindreading to implicit metacognition, one might object that the mechanisms, development and interaction of implicit forms do not directly correspond to those of explicit forms. In addition, although this study aimed to test the idea whether mindreading is an overarching framework of metacognition and based on their findings the authors argued that it is not, the findings may be even interpreted as implicit metacognition not being part of metacognition (see Carruthers, 2009a, 2009b; but see Proust, 2019). Therefore, more studies are needed to better understand the relationship documented in their study.

Notably, one recent study by Nicholson, Williams, Grainger, Lind and Carruthers (2019) tested adult participants with autism and their neurotypical counterparts on explicit mindreading (reading the mind in the eye task and a verbal description of mental state attribution to animated geometrical shapes) as well as on implicit and explicit metacognition. They found that participants with autism showed less accurate explicit metacognitive judgments than their counterparts whereas no group difference was observed for implicit metacognitive performance. They also found that explicit mindreading was related to explicit metacognition, but not to implicit metacognition; explicit metacognition was also not related to implicit metacognition. Based on these findings, they argued that there is a single cognitive process and system for mindreading and explicit metacognition and that implicit metacognition is not part of it (i.e., it does not involve metacognitive abilities). We will return to their interpretations in the Discussion. No studies, however, directly investigated the relationship between mindreading and metacognition (in their explicit and implicit forms) in young children.

1.4. The present study

The present study aimed to fill in the gap in the literature by systemically investigating cultural differences (or lack of difference) in metacognition in both implicit and explicit forms in direct comparison to cultural variations in mindreading, at four years of age. This study aims to contribute not only to the current state of knowledge on an early development of metacognition across different cultures, but also, importantly, to the understanding of the relationship between the development of metacognition and the

development of mindreading, through a focus on the influence of cultural experience on the development. It is thus meant to offer new insights for the theoretical debate on the relations between metacognition and mindreading (e.g., Carruthers, 2009a, 2009b; Lecce et al., 2015; Lockl & Schneider, 2007; Perner, 2000; Proust, 2013). We specifically targeted two cultural groups, Japanese and German children for the current study, because there is some evidence that Japanese children pass the standard verbal false belief tasks one or even two years later than Western children (e.g., Naito & Koyama, 2006) and that German children's false belief performance mirrors that of children from the typical Western countries (e.g., Mayer & Trauble, 2015). We also do not know whether Japanese children's false belief performance reflects their understanding of epistemic states more generally. We tested 4-year-olds because it is the age at which false belief understanding is greatly developing – at least in Western countries. Finally, the performance gap between implicit and explicit metacognition was previously documented with German children in the same task we adopted for the present research (see below).

The present study, therefore, had two interrelated aims. First, we asked whether there is a cultural difference in metacognitive abilities at the age of four. We specifically asked whether or not the discrepancy between implicit and explicit metacognition documented in prior studies is observed in 4-year-old children developing in Germany and Japan. Second, we aimed to examine more closely the relationship between explicit mindreading, explicit metacognition and implicit metacognition. More specifically, we asked the following questions. Are explicit and implicit metacognition related? Is explicit metacognition related to explicit mindreading? Finally, is implicit metacognition related to explicit mindreading?

In the present research, we therefore tested both German and Japanese children's mindreading and metacognitive abilities. In order to assess children's metacognitive abilities, we relied on an experimental design developed by Kim et al. (2016) that consisted of two tasks: An explicit metacognitive task modeled on Rohwer et al. (2012) and a nonverbal, implicit version (the "informing task"). Kim et al. (2016) confirmed the gap between the two in the theoretically relevant 'partial knowledge' condition. The design of this study, therefore, offers an appropriate test case for investigating cultural differences. It allowed us to explore whether or not children from these two groups perform better in the implicit than in the explicit tasks and to test the theoretical accounts of the relationship between metacognition and mindreading. Although the partial knowledge condition is critical for the purpose of the present research, however, given that we did not know how Japanese children would perform in these conditions, we decided to test children in all three conditions.

Moreover, in order to investigate cultural difference in explicit mindreading and in order to test claims on a relation between mindreading and metacognition, we assessed children's false belief competence. To this end, we relied on two established tasks (Wellman & Liu, 2004). Note that prior studies of a relation between mindreading and metacognition exclusively measured explicit meta-memory (e.g., Lecce et al., 2015; Lockl & Schneider, 2007). Note also that no preexisting studies of meta-memory tested the same children in both implicit and explicit forms and thus by adopting Kim et al. (2016) our explicit task measured meta-knowledge. Moreover, a difference between our explicit metacognition and explicit mindreading tasks concerned respectively self-directed outcomes (my knowledge states) vs. other-directed outcomes (others' knowledge states) and thus the tasks were deemed more comparable to one another. Please note that we had attempted to test the same children in an implicit version of the false belief task by adopting Clements and Perner's (1994) design in order to test the relationship between implicit mindreading and implicit metacognition. Yet, a pilot test revealed that all German children either failed to engage in the task or did not reliably display an expected pattern of eye gaze. This pattern is indicative for the volatile nature of some of these tasks, as argued in the context of the current dispute on the nature of implicit mindreading (Poulin-Dubois et al., 2018). Therefore, we decided to exclude this task from the present study (see also Kulke, von Duhn, Schneider, & Rakoczy, 2018).

Given the theoretical account and evidence in favor of a close relationship between mindreading and metacognition together with evidence of cross-cultural variations in the development of mindreading (e.g., Chandler & Carpendale, 1996; Kuhn, 2000; Lockl & Schneider, 2007), there are reasons to expect a similar pattern of cultural differences in metacognition. Thus, Japanese children's explicit metacognition of their own knowledge might be expected to be slower to develop than that of German children in an explicit metacognitive task, as they are in false belief tasks. Alternatively, based on the reasons detailed earlier, we may find a different pattern of performance in metacognition.

Our implicit metacognitive task consists in accepting/ refusing to inform an ignorant person. Implicit metacognition is thought to be less impacted than explicit metacognition by cultural and language diversity (Heyes & Frith, 2014). Therefore, we expect Japanese children to be as sensitive as German children to their own ignorance, on implicit measures. Although Nicholson et al. (2019) found no relationship between implicit and explicit metacognition in both groups of adults (neurotypical and autism patients), there is no priori reason to expect the same findings with young children. How implicit metacognition develops in relation to explicit mindreading remained exploratory in the present study, given that the only existing developmental study showed no relationship between implicit metacognition and explicit mindreading (Bernard et al., 2015; see also Nicholson et al., 2019 for adults) which is subject to different interpretations as discussed earlier (e.g., mindreading is not an overarching mechanism for metacognition; implicit metacognition is not part of metacognition).

2. Method

2.1. Participants

Four-year-old Japanese children ($N = 39$, Mean age = 4.55, Range = 4.08–4.90, 18 girls) and German children ($N = 37$, Mean age = 4.54, Range = 4.09–4.97, 20 girls) participated. Children from both countries were largely from middle or upper middle class families living in a fairly large city. All children were native German or Japanese speakers. The sample size was doubled in the

present research based on prior studies (n = 19 in Kim et al., 2016; n = 16–21 per age group in Rohwer et al., 2012 l; also n = 21 Nicholson et al., 2019). Achieved power ranges between 73 and 96 as reported below in the Results.

2.2. Materials

The stimuli used in the metacognitive tasks were modeled after those from Kim et al. (2016). Different toys were used for Japanese and German children because they were chosen based on familiarity to each cultural group. In each test site, toys were selected based on availability in a local toy store; during the piloting we tested the familiarity of each item with several old 3-year-olds. At the end of the metacognitive test session, individual children were asked to identify all the toys. No child failed to identify the toys used in the testing.

2.3. Design and procedure

All children received three tasks in the following order: an implicit form ('informing task') and an explicit form of the metacognitive task ('explicit task') followed by two false belief tasks. The fixed order of the tasks was used after considering the suggestion that a fixed order is a standard procedure for studying individual differences and relations among different tasks (see Carlson & Moses, 2001). In particular, children received the implicit task prior to the explicit task to ensure that their explicit judgments do not subsequently influence implicit judgments (see also Nicholson et al., 2019).

In both metacognitive tasks, children received three conditions, two trials per condition in a counterbalanced order. A manipulation of the conditions was adapted from Rohwer et al. (2012). In the Ignorance condition, children did not see any objects, were told one object would be hidden in the container, and the object was hidden out of children's sight. In the Partial Knowledge condition, children saw two different objects, were told that one of them would be hidden inside the container, and the object was hidden out of children's sight. In the Full Knowledge condition, children viewed the contents of a container and then the lid of the container was placed. In this condition, a brief delay (5 s) was administered before the experimental question was asked. In the informing task, another person (Max) was present, right next to each child participant but his/her view to the container was blocked in all conditions; in every trial, children were asked whether they would choose to inform this person about the contents of the container. If they chose to inform, then they were invited to verbally inform Max. If they declined to inform, then the experimenter informed Max. In the explicit task, in every trial, children were asked whether they did or did not know what was inside the container. If children responded that they knew the content of the container, they were asked the following two questions: "Okay, then tell me what's inside the box?" and "Do you really know or are you just guessing?"

In addition, children received two false belief tasks in a fixed order: a 'Sally Ann object transfer' and a 'Paul Backpack' verbal task. The Sally Ann task is a standard task being widely used in the field (Liu et al., 2008). The Paul-Backback verbal task is a version of the false belief task in which a protagonist's false belief is verbally described (Welllman & Bartsch, 1988). See Appendix for the detailed description of these two tasks.

2.4. Coding

The coding of the informing task followed Kim et al. (2016). In the Full knowledge condition, children received a score of 1 if they agreed to inform and accurately reported the object identity to Max and a score of 0 if they declined to inform; In the Partial Knowledge and in the Ignorance conditions, children received a score of 1 if they declined to inform or if they agreed to inform but verbally indicated their uncertainty or ignorance about object identities to Max (e.g., "Hmm," "I don't know"). The coding for the explicit task followed Kim et al. (2016) and Rohwer et al. (2012). In the Full Knowledge condition, children received a score of 1 if they correctly reported their own knowledge, and a score of 0 if they did not. Those children who responded that they knew all accurately reported the object names and further responded that they really knew rather than guessing. In the Ignorance condition and the Partial Knowledge condition, children received a score of 1 if they acknowledged their ignorance. In the original coding, children also received a score of 1 in these conditions if they erroneously indicated an object name to the test question, but acknowledged that they were guessing when asked the follow-up question. No child, in our study, belonged to this response category, however.

For each false belief task, children received a score of 1 if they gave correct responses to all questions including a test question as well as control questions; otherwise, a score of 0.

2.5. Data analyses

A logistic regression analysis was conducted to compare between two cultural groups on mindreading. Another logistic regression analysis was conducted to compare between two cultural groups on metacognition. Finally, a series of regression analyses that closely follow those of Nicholson et al. (2019) was conducted to examine the relationship between mindreading and metacognition.

Table 1
The number of children who are scored 0, 1, and 2.

	Scored 0	Scored 1	Scored 2
Japan (N = 39)	25	10	4
Germany (N = 37)	14	13	10

3. Results

3.1. Cultural group comparisons on mindreading and metacognition

3.1.1. Mindreading

Table 1 presents the number of children who received a score of 0, 1, and 2. In order to examine whether German and Japanese children differed in their false belief performance, a logistic regression analysis was performed. German children outperformed Japanese children in the false belief task. (B = 0.821, SE = 0.408, p = .044, Exp (B) = 2.273, CI = [1.021, 5.059], achieved power = 0.88).

3.1.2. Metacognition

Fig. 1 presents the proportion of accurate trials as a function of Country, Condition and Task type.

A logistic regression with Country, Task type and Condition as predictors (the latter two as repeated variables) was conducted to examine cross-cultural differences in children's metacognition. Condition was significant (Wald χ^2 = 53.464, p < .0001), as was the interaction of Task type X Condition (Wald χ^2 = 16.819, p < .001). Children performed better in the explicit than in the informing task in the Full knowledge condition (B = 1.006, SE = 0.347, p = .004, Exp(B) = 2.733, CI = [1.384, 5.398], achieved power = 0.96) but they performed better in the informing than in the explicit in the Partial knowledge condition (B = 0.666, SE = 0.205, p = .001, Exp(B) = 1.947, CI = [1.304, 2.908], achieved power = 0.74). Children's performance did not significantly differ between the two tasks in the Ignorance condition (B = −0.039, SE = 0.263, p = .882, Exp(B) = 0.962, CI = [0.575, 1.609]). Most important for our research question: Children in both cultural groups performed better in the informing than in the explicit task in the partial knowledge condition (Japan: B = 0.693, SE = 0.319, p = .030, Exp(B) = 2.000, CI = [1.070, 3.737] achieved power = 0.77; Germany: B = 0.656, SE = 0.261, p = .012, Exp(B) = 1.928, CI = [1.155, 3.218], achieved power = 0.73). German and Japanese children performed similarly in the implicit task (B = −0.096, SE = 0.229, p = .676, Exp(B) = 0.909, CI = [0.580,

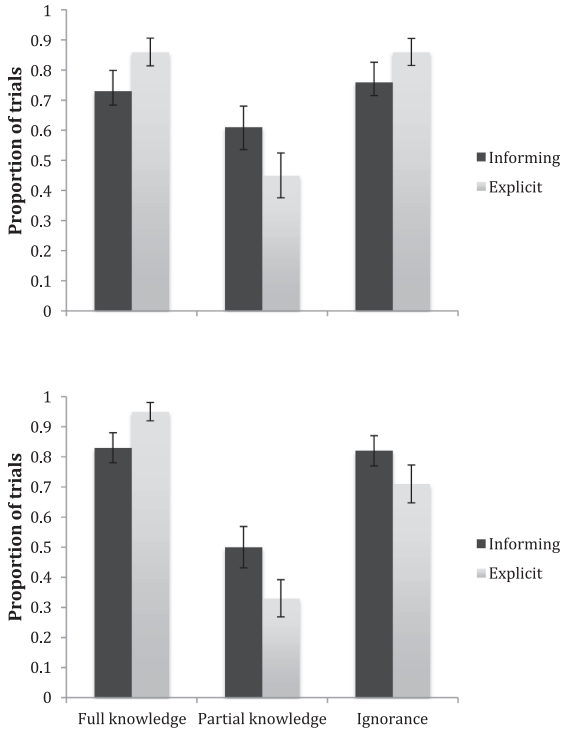

Fig. 1. The proportion of trials in which children provided accurate responses as a function of Country (Germany: upper panel; Japan: lower panel), Condition and Task type. Error bars indicate standard error.

Table 2
Correlation coefficients (Upper: German children; Lower: Japanese children). **$p < .001$.

	1. Mindreading	2. Implicit (informing)	3. Explicit
1.		0.023	0.125
2.			0.618**

	1. Mindreading	2. Implicit (informing)	3. Explicit
1.		−0.108	−0.268
2.			0.518**

1.423]) and in the explicit task ($B = 0.297$, $SE = 0.221$, $p = .179$, Exp(B) = 1.345, CI = [0.873, 2.072]). The Bayes factor (null/alternative) further suggested "substantial" evidence for the null over the alternative hypothesis for the implicit (Bayes factor = 3.279), and the explicit (Bayes factor = 3.056) task (Jeffreys, 1961 on Bayes factor interpretations). None of the other main effects or interaction effects were significant, including the main effect of Country or any interaction involving Country.

3.2. The relationship between mindreading and metacognition

In order to directly test theoretical accounts of the relationship between mindreading and metacognition, a series of regression analyses closely followed those conducted by Nicholson et al. (2019) except that we also included Group as a variable. We confirm, however, that excluding Group does not change any of the results reported here. An average FB scores across two FB tasks and an average metacognitive score across three conditions were used. We confirm that data analyses considering only the partial knowledge condition yielded the same findings as reported below. Table 2 presents correlation coefficients between variables for each cultural group.

3.2.1. Relation between implicit (informing) and explicit metacognitive task performance

First, we asked whether implicit and explicit metacognition are related to each other to the same extent across two cultural groups. Children's scores in the informing task was significantly predicted by the explicit task scores and remained significant in Block 2 but the interaction of explicit scores X cultural Group was not significant, indicating that the relationship between informing and explicit performance was not different by cultural Group (Table 3).

3.2.2. Relation between mindreading and performance on the explicit and the implicit metacognitive task

We asked whether mindreading is related to either the explicit or the implicit metacognition in the same extent across two cultural groups. Children's mindreading did not significantly predict informing scores and it remained non-significant and the interaction of Mindreading and cultural Group was also not significant in Block 2 (Table 4). Likewise, children's mindreading did not predict explicit scores which remained non-significant; the interaction of Mindreading and cultural Group was not significant in Block 2 (Table 4).

4. Discussion

The present research provides the first evidence of no performance difference between 4-year-old German and Japanese children with respect to the implicit and the explicit forms of metacognition. Japanese children's performance in explicit mindreading at four years of age, by contrast, was lower than that of their German counterparts. Finally, implicit and explicit metacognition were related but neither was related to mindreading; no group difference was observed. We will discuss these findings below in more detail.

4.1. Mindreading differences

In the present study, 4-year-old German children outperformed their Japanese counterparts in the false belief tasks. This finding is

Table 3
Relation between implicit (informing) and explicit metacognitive task performance.

	B	*SE*	*β*	*t*	*p*
DV: Implicit scores					
Block 1					
Explicit scores	0.602	0.105	,554	5.729	< 0.001
Block 2					
Explicit scores	0.571	0.149	0.526	3.834	< 0.001
Group	−0.127	0.154	−0.286	−0.822	0.414
Explicit scores X Group	0.106	0.213	0.186	0.496	0.621

$R^2 = 0.307$ for Block 1 ($p < .001$) R^2 change = 0.876 for Block 2 ($p = .421$).

Table 4
Relation between mindreading, and performance on the implicit (informing) and explicit metacognitive task.

	B	*SE B*	*β*	*T*	*p*
DV: Implicit scores[a]					
Block 1					
Mindreading	−0.026	0.067	−0.046	−0.392	0.696
Block 2					
Mindreading	−0.071	0.108	−0.123	−0.659	512
Group	−0.036	0.071	−0.081	−0.503	0.616
Mindreading X cultural Group	0.084	0.143	0.135	0.588	0.558
DV: Explicit scores [b]					
Block 1					
Mindreading	−0.007	0.062	−0.0133	−0.109	0.913
Block 2					
Mindreading	−0.160	0.096	−0.301	−1.662	0.101
Cultural Group	−0.001	0.064	−0.003	−0.019	0.985
Mindreading × cultural Group	0.223	0.128	0.390	1.751	0.084

[a] $R^2 = 0.002$ for Block 1 ($p = .696$) R^2 change = 0.005 for Block 2 ($p = .831$).
[b] $R^2 = 0.000$ for Block 1 ($p = .913$) R^2 change = 0.067 for Block 2 ($p = .081$).

consistent with the prior studies reporting that Japanese children pass these tasks at an older age compared to children from Western countries such as US, UK or Germany (e.g., Naito & Koyama, 2006). It supports the view that the development of mindreading is modulated in part by cultural factors and provides further support for cross-cultural variation in mindreading (e.g., Mayer & Trauble, 2015; Vinden, 1999; Lillard, 1998). For example, Matsui, Rakoczy, Miura, and Tomasello (2009) showed that 3-year-old Japanese children's understanding of others' false belief benefited from a linguistic marker being produced by the speaker who had a false belief, expressing his/her certainty in the statement; in contrast, German children's understanding failed to be boosted. Thus, whereas Western children as observers of others' behaviors may spontaneously attribute mental states (including false belief) to others, Japanese children's interpretation of others' mental states may be not as automatic or spontaneous as their counterparts unless it is clearly marked by the speaker herself.

4.2. Similarity in metacognition

The present study was motivated by the scarcity of cross-cultural developmental studies in metacognition –in contrast with the bulk of cross-cultural studies in mindreading. In light of the theoretical discussions on the relationship between metacognition and mindreading (see more below 4.3), we used Kim et al.'s (2016) paradigm to investigate 4-year-old Japanese and German children's explicit and implicit metacognition. Children were asked in the explicit task to verbally report whether they did or did not know the hidden contents of a container. In the informing task, in contrast, children were asked to decide whether they would inform another person who did not know the hidden content. Kim et al. (2016) found that, in the partial knowledge condition, 3- to 4-year-old German children tended to overestimate their knowledge states in the explicit task, but did not do so in the informing task. Likewise, our present study documents a performance discrepancy between the explicit and the implicit task in the partial knowledge condition – with little difference between 4-year-old Japanese and German children. This result suggests that metacognition and mindreading – at least at the age of 4 – do not strongly relate to one another. However, we fail to replicate the prior findings of Kim et al. (2016) in the full knowledge condition. Whereas in the full knowledge condition, children in the present research were more sensitive to their knowledge states in the explicit task than in the informing task, German children had been equally good in the two tasks in Kim et al. (2016). The present study does not provide a conclusive answer to the current finding. However, it is possible that despite the fact that children have a reliable 'feeling of competence' (Rohwer et al., 2012) in the full knowledge condition, having to inform an unknown person in the informing task may have led children to be reluctant to inform someone.

4.3. Relation between metacognition and mindreading

The present findings directly shed new light on the relationship between metacognition and mindreading. From a theoretical viewpoint, it has been proposed that mindreading and metacognition are closely related to one another because both not only concern mental states and processes, but represent them, which requires meta-representing first-order thoughts as being beliefs, perceptions, memories, etc. (e.g., Kuhn, 2000; Perner, 2000). In particular, according to Carruthers (2009a, 2009b), both mind-reading and metacognition are governed by an overall metarepresentational system of informational processes. Supporting this idea, a recent empirical study by Nicholson et al. (2019) documented a relation between explicit metacognition and mindreading in both groups of adults with autism and neuro-typical adults. In addition, their study did not find a relation between explicit mindreading and implicit metacognition or between explicit and implicit metacognition.

Despite a comparable similarity in design, our study testing 4-year-old children revealed a pattern of findings different from Nicholson et al. (2019). We found that explicit and implicit metacognition were related to one another with no overall difference between German and Japanese children. Mindreading was unrelated to either implicit or explicit metacognition, again, with no group

difference. Our findings suggest a similarity in the early development of metacognition across culture, independent of the development of mindreading. A recent study indicates that different brain regions may be involved for explicit metacognition (accurate explicit metacognitive judgments in the partial knowledge condition) and mindreading in 5- and 6-year-old children (Filevich et al., in press). These findings seem to challenge the one-system view.

Our results further suggest that metacognition and mindreading in their early development may involve different processes, having specific developmental patterns. This does not mean, however, that these developmental processes do not overlap and interact over the course of the development. The studies documenting the relation between mindreading and metacognition suggest that mindreading is predictive of, and causally responsible for, later explicit metacognition (e.g., Lecce et al., 2015). Given that we tested only 4-year-old children, therefore, how metacognition and mindreading might interact with one another with increasing age remains unsolved. Future investigations into the exact processes subserving each group of abilities, and the nature of their developmental interaction in older age groups will greatly contribute to the literature. Although our study failed to adopt an implicit FB task, future studies should also investigate relationships between metacognition and mindreading including implicit mindreading.

It is also possible that children from both countries might not differ in their metacognition, whether implicit or explicit, because the social norms and expectations constraining the attribution of false belief to others, or mindreading in general, do not apply to expressing one's own ignorance, tested in the explicit task, or to informing others tested in the informing task. In addition, Rohwer et al. (2012) argued that for the attribution of knowledge to oneself young children rely upon their own “feeling of competence” whereas for the attribution of knowledge to others they rely upon the presence or absence of informational access (c.f., Wimmer, Hogrefe, & Sodian, 1988). Thus, young children’s evidential basis of knowledge attribution to oneself vs. others may be initially disjointed in early development (see Harris, 2018); cultural variance of mindreading may thus be explained in terms of the kind of evidence that is recruited for judging others’ mental states (as already discussed above: Japanese children specifically rely on speaker’s uncertainty in false belief tasks). Given that, unlike our own feeling of competence, we do not immediately have access to others’ feelings of competence, a further question to explore is whether children (and adults) rely upon others’ verbal or non verbal expression of feelings of competence for attributing knowledge states to others.

Moreover, the dissociation that we document between metacognition and mindreading may also track important functional differences. The function of metacognition consists in controlling one's own cognitive actions by monitoring one's own epistemic properties. In our task, children had to choose whether or not to inform another person or to explicitly respond whether they did or did not know what object was in the box as a function of the kind of perceptual information they had received. The function of mindreading, in contrast, has to do with epistemic vigilance, i.e. with the prediction of others' mental states and likely behaviors, and with their trustworthiness. False belief tasks, in particular, are functionally important because children should be able to identify not only the mental states of others, but also the circumstances in which communication by others of inaccurate belief contents depends on the world having changed, rather than on intentional deception.

Finally, note that we only tested a specific kind of metacognition. There are various forms of metacognition such as expressing confidence in one's own perception, memory, reasoning, learning, being sensitive to new information, to incoherence, etc. Yet, little is known about how all these different forms of metacognition relate to one another and develop with increasing age and cross culturally. In addition, we only tested children developing in two countries, Japan and Germany, both of which are highly industrialized societies with the early presence of formal educational systems. Thus, our findings of no cultural difference in young children’s metacognition can in no way preclude us from finding cultural influence in wider range of cultural diversity. Finally, although our sample size was larger than that of previous studies in this area (Kim et al., 2016; Rohwer et al., 2012), it is still relatively small. Additionally, although the Bayes factors provided evidence in support of the null over the alternative hypothesis the evidence was not considered as “strong” or “decisive” (Jeffreys, 1961) – one likely reason being the small number of trials in the condition. Thus, a replication with a larger sample size and more number of trials just focusing on the partial knowledge condition would be valuable. The present research, therefore, calls for more cross-cultural studies of young children’s development of metacognition and mindreading.

CRediT authorship contribution statement

Sunae Kim: Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing. **Beate Sodian:** Conceptualization, Methodology, Writing - review & editing. **Markus Paulus:** Conceptualization, Methodology, Writing - review & editing. **Atsushi Senju:** Conceptualization, Methodology, Writing - review & editing. **Akiko Okuno:** Data collection. **Mika Ueno:** Data collection. **Shoji Itakura:** Conceptualization, Methodology, Writing - review & editing. **Joélle Proust:** Conceptualization, Methodology, Writing - review & editing, Funding acquisition.

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Appendix

Paul-Backpack false belief task:

This is Paul. Paul wants to find his gloves. Paul’s gloves might be in his backpack [point to the picture of a backpack] or in the

closet [point to the picture of a closet]. Good! Paul's gloves are really in his backpack [point and make a short brake] – but Paul THINKS, that his gloves are in the closet [point].

Control question: Where are Paul's gloves really? Are the gloves in the backpack or in the closet?

Target Question: Now, where will Paul [point at Paul] look for his gloves, in the backpack or in the closet?

Sally- Ann false belief task:

This is Sally and this is Ann. Which one is Ann (Sally)? Good. Sally got a bag and Ann got a chest. Sally got a marble. Sally put her marble into her bag to keep them safe while she goes outside to play [move Sally out of the table]. While Sally is outside naughty Ann moves the marble from Sally's bag into her chest. [put Ann away from the table]

Control question 1: Where is the marble now?

Control question 2: Where did Sally put the marble in the beginning?

Target question: Now when Sally comes back from her play where would she look for her marble?

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